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Description

Multipole, permanent-magnet rotor for a rotating electrical machine, and a method for producing such a rotor

The invention relates to the field of rotating electrical machines, and is applicable to the design configuration of rotor cores which are fitted with permanent magnets using what is referred to as flux concentration construction.

Now that special permanent magnets, referred to as hard ferrite, have been successfully developed, which are matched to the stringent requirements of electrical machines, such magnets have now been used to an ever greater extent to produce the rotating magnetic field in the rotating electrical machines. Various options for the arrangement of the permanent magnets in the rotor or in the stator have been developed for motors and generators with rated powers up to 30 kW at 3000 rpm. In this case, what is referred to as the "flux concentration construction" has been found to be the technically better solution above a rated power of several hundred watts. One embodiment of this construction is to arrange the permanent magnets in the pole gaps in the rotor (Siemens Journal 49, 1975, Issue 6, page 368 et seq./369, Figure 3). One known design solution for this purpose is to arrange the permanent magnets, which have a flat rectangular cross section and are designed to be flat in the magnetization direction, radially with respect to the rotor axis in slot-like spaces in each case between two yokes that are fixed on the rotor body (EP 0 582 721 B1).

In another known rotor, fitted with permanent magnets, for an electrical machine, poles which are welded to a hollow

rotor shaft are shaped in such a manner that there is an accommodation area with a trapezoidal cross section between two poles, for permanent magnets which likewise have a trapezoidal cross section. The outer surface of the rotor is in this case formed by shrunk-on reinforcements composed of a copper-beryllium alloy (US 4,242,610).

With regard to the handling of permanent magnets when constructing rotors of electrical machines, it is furthermore known for the magnet bodies to be installed in the unmagnetized state and to be magnetized once they have been arranged on the rotor, for example using the stator winding of the electrical machine (EP 0 195 741 B1).

Such magnets which store a large amount of energy, for example based on neodymium-iron-boron (NeFeB), have been developed recently, the use of permanent-magnet rotors is now feasible even for electrical machines with a rated power of more than 100 kW, for example in ship propulsion systems with a rated power of 5 to 30 W. Machines such as these have a rotor diameter of more than 25 cm up to about 300 cm. If the rotors of machines such as these are constructed using flux concentration, this involves difficulties in the installation and securing of the magnets.

Against the background of a permanent-magnet rotor having the features in the precharacterized clause of patent claim 1, the invention is based on the object of designing the rotor construction such that the permanent magnets can be stored without exerting large amounts of force.

In order to achieve this object, the invention provides for each yoke to be subdivided in the circumferential

direction into two half yokes, which each extend over half of one pole pitch, and that the two mutually adjacent half-yokes of two yokes arranged alongside one another are in each case connected by means of end points to form a pole element, and each pole element is fixed on its own on the rotor body. In this case, the pole elements can be designed such that either each of the two half-yokes is fitted with permanent magnets on its surface facing a slot-like intermediate space, or such that only one of the two half-yokes is fitted with permanent magnets on the surface facing the other half-yoke. If the permanent magnets are arranged on the corresponding surfaces of the half-yokes and of the pole elements on the rotor body, it is expedient for the magnets to be fitted to the half-yokes in the unmagnetized state, and for the magnets to be magnetized once the two half-yokes have been joined together to form a pole element, but before the pole elements are fitted onto the rotor body.

Such a configuration of the poles and association between the magnets and the poles of the rotor allows both the pole elements, which comprise the half-yokes and magnets, and the individual magnets to be handled without exerting any excessive force while being arranged - generally by bonding - on the corresponding surfaces of the half-yokes. In the case of relatively long rotors, it is also recommended that the individual pole elements be subdivided into a number of partial pole elements in the axial direction of the rotor, in order to produce convenient units which are easy to magnetize.

When the individual parts of a pole element are being joined together, it may be expedient to fill the spaces which remain between the two half-yokes with a material which expands under the influence of impregnation resins. Furthermore,

the permanent magnets which are arranged between the half-yokes can also be secured in the radial direction by double wedges, which are supported on corresponding projections on the half-yokes.

The two half-yokes which form a pole element are in each case expediently connected by means of two preferably amagnetic end plates, which are screwed and pinned to the two half-yokes and permanently fix the two half-yokes with respect to one another. Once the pole elements have been assembled, they can be provided with surface protection by subsequent impregnation with a resin which, in particular, protects the corrosion-sensitive permanent magnets permanently against damaging influences.

Once the pole has been magnetized, they are placed on the tubular rotor body, and are screwed to it from the inside or outside. The rotor body is in this case preferably amagnetic.

The configuration of permanent-magnet rotors provided according to the invention can be applied both to machines with an internal rotor and to machines with an external rotor. External rotor machines may be, in particular, generators in wind power systems, or drive motors for hoist systems.

Three exemplary embodiments of rotors designed and produced according to the invention are illustrated, in detail form, in Figures 1 to 5, in which:

Figure 1 shows a first exemplary embodiment of the configuration of the poles and yokes,

Figure 2 shows a front view of a pole element designed according to the invention,

Figure 3 shows the subdivision of a pole element into a number of partial pole elements,

Figure 4 shows a second exemplary embodiment of the configuration of poles and yokes, and

Figure 5 shows the configuration of poles and yokes arranged on an external rotor.

Figure 1 shows, in the form of a detail, a cross-sectional region of a rotor of an electrical machine, which comprises a rotor body 1, rotor yokes 2/3 mounted on the rotor body 1, and permanent magnets 5 mounted on the rotor yokes. Each rotor yoke is in this case subdivided into two half-yokes 2, 3, with a slot-like intermediate space 4 being provided between each two yokes. The permanent magnets 5 are magnetized in the circumferential direction and are arranged in the slot-like intermediate spaces 4, with one permanent magnet 5, or one magnet layer comprising a large number of relatively small permanent magnets, in each case being arranged on that surface of the respective half-yoke which faces the slot-like intermediate space 4. The permanent magnets 5 are in this case normally bonded to the half-yoke 2 or 3. Alternatively, the two magnet layers can also be associated with only one of the two half-yokes.

The space which remains between two half-yokes 3 and 2 and between the mutually adjacent permanent magnets 5 may be filled, if required, with a material 9 which can expand under the influence of impregnation resin. Furthermore, to provide radial fixing for the permanent magnets 5, double wedges 8 can be arranged both between the rotor body 1 and the permanent magnets, and between the permanent magnets and the periphery of the rotor.

According to Figure 2, two half-yokes 3, 2 are associated with different yokes are in each case joined to the permanent magnets 5 arranged on the corresponding side surfaces, by means of end plates 6, to form a pole element 7. A number of such pole elements are arranged independently of one another on the circumference of the rotor body 1, and are connected to the rotor body, for example by means of a screw joint.

During the production of the pole elements 7, it is expedient firstly to arrange, for example to bond, the permanent magnet (which has not yet been magnetized) on the corresponding side surface of the half-yoke 2 or 3. Two half-yokes 2, 3 are then associated with one another, and are fixed with respect to one another by means of two end plates 6. After this, the pole element 7 that has been produced in this way is inserted into a magnetization apparatus, and the permanent magnets 5 are magnetized. The magnetized pole element 7 can then be arranged on the rotor body 1.

In electrical machines having a relatively long rotor, it is recommended that the respective pole element 7 be subdivided into partial pole elements 73 in the axial direction of the rotor, as is illustrated in Figure 3. In this case, a number of partial pole elements as illustrated in Figure 2 are then arranged axially one behind the other on the rotor body.

Figure 4 shows a variant of Figure 1. In this case, the half-yokes 2′, 3′ are assigned such that there is a cavity 71, which acts as a flux barrier, between them. The proportion of the magnetic flux produced in the individual half-yokes by the stator winding can then be influenced via this cavity.

The rotor illustrated in Figure 5 is an external rotor with an externally arranged supporting body 11. The arrangement of half-yokes 2'' and 3'' and the configuration of the permanent magnets 5 corresponds in principle to the exemplary embodiments shown in Figures 1 and 4. In this case, in contrast to Figure 4, a V-shaped, flux-free area 72 is provided between each two half-yokes.